Letters to the Editor

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On the Measurement of Ionospheric Virtual Height at 100 Kilocycles*

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November 20, 1947

STUDIES of the reflection of atmospherics by the ionosphere[1,2] have indicated that the effective height of the reflecting region lies between about 60 and 90 kilometers at very low frequencies. Continuous wave interference measurements[3] made at 16 kilocycles at oblique incidence have been interpreted to indicate that the effective height of the reflecting layer rises from 70 or 75 kilometers by about 12 kilometers at the time of sunset.

Further evidence on the height of the ionosphere at low frequencies has been obtained with a pulse technique applied at vertical incidence at a frequency of 100 kilocycles. The method is similar to that used at high frequencies where virtual height is determined from the time required for a pulse of radio energy to travel to the ionosphere and back. A pulse of approximately exponential decay is produced every second by allowing an antenna which is charged to a potential of about 100 kilovolts to discharge to ground through a sphere gap. This pulse, which has a time constant of about 200 microseconds, travels by way of the ground and the ionosphere to the receiver located 2.7 kilometers away. The peak power radiated vertically is about 500 watts.

The receiving antenna is a forty-foot dipole whose directional characteristic is used to discriminate against the ground pulse which would otherwise override the relatively weak ionospheric reflections. It is possible by this means to reduce the dipole response to the ground pulse to about sixty decibels below the maximum response. Discrimination of the same order of magnitude is obtained against most of the interfering signals and atmospherics which are present. The over-all band width of the receiving system is eighteen kilocycles. Results are displayed on a five-inch oscilloscope and recorded photographically. The sweep is triggered by the ground pulse picked up on a separate receiver having a shorter time delay than that used to receive the sky-wave signals.

Measurements made on the night of October 13 showed virtual heights ranging from about 91 to 98 kilometers in a group of thirty-three records. A sample of the records is shown in Fig. 1. The negative pips are timing markers spaced 167 microseconds apart corresponding to a virtual height of twenty-five kilometers. A reflected pulse is observed at about 95 kilometers and a first multiple at about 190 kilometers. These values are corrected for the time required for the ground pulse to travel over the 2.7-kilometer base line. The virtual heights measured from the multiple reflections, which were observed on a majority of the records, were in good agreement with those measured from the first reflections except in two or three cases.

On several occasions a characteristic effect which has been noted at high frequencies was observed on 100 kilocycles; namely, the amplitude of the first-order multiple was often greater than that of the first reflection. This is evidence of horizontal ion gradients such as might result from the action of winds in the ionosphere.

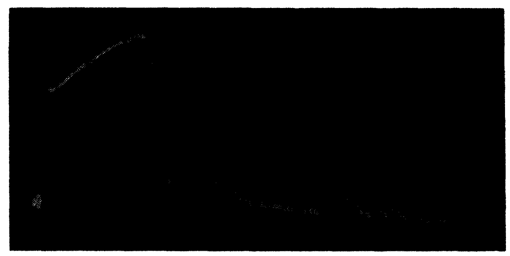

FIG. 1. Photograph of single sweep showing receiver-limited ground pulse followed by ionospheric reflections at virtual heights of 95 and 190 kilometers. Heights are measured with aid of the negative pips spaced 25 kilometers apart.

The ionosphere sounding technique described above should make it possible to fill an important gap in existing information on the ionosphere and to obtain a better understanding of the effect of the ionosphere on the propagation of low frequency waves.

* This work was sponsored by the National Bureau of Standards.
[1] Schonland, *et al.*, "Reflection of atmospherics from the ionosphere," Nature, May, 893 (1939).
[2] Laby, *et al.*, Nature **142**, 353 (1938).
[3] J. E. Best, J. A. Ratcliffe, and M. V. Wilkes, Proc. Roy. Soc. **156**, 614 (1936).

The Crystal Counter

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August 22, 1947

RECENTLY the problem of a crystal counter has been discussed.[1] The following remarks may be of interest: In order to detect single α-particles by means of a crystal counter alkali halides, sulfur, zincblende, and diamond crystals were investigated by G. Stetter, K. Huber, and the author, in 1940.[2] As expected, the alkali halides and the sulfur failed. The available zinc-sulfide crystal too was not useful, probably because of impurities.

Two chips of white diamonds, 0.4 mm thick, had a high photo-conductivity. We observed with them pulses produced by α-particles in a device similar to that mentioned by Wooldridge, Ahearn, and Burton,[1] using cathode sputtered gold electrodes. In the absence of light the insulation was perfect. An electric field strength of 3000 volts per cm being applied, the pulses produced by α-rays of polonium or thorium were very sharp. The time constant of the amplifier was 10^{-3} sec.

The number of ions was generally of the same order as measured in an ordinary gas chamber; the number of registered pulses was smaller than the number of the absorbed α-particles.

In spite of the homogenous energy of the α-particles the magnitudes of the single pulses were very different from one another. Special experiments proved that the reason for this result was not the difference in pathway between the place of origin of the electrons and the anode.

Alpha-particles penetrating the crystal either at the anode or at the cathode side produced about the same distribution of pulses.

Single outstanding values of pulses of higher energy than that of a single α-particle were sometimes registered. The same field strength being applied saturation in photoconductivity was measured as expected.

For the explanation of the results the following may be pertinent: The α-particles penetrate only the surface layer of the crystal. Further the density of ionization by light is quite different from the ionization by α-rays which produce local lattice disturbances because of their high ionization density.

A sudden discharge of [the produced] space charge may be considered as an explanation of some of the pulses, especially the larger ones.

Regarding the experiments mentioned above, it is believed that a quantitative measurement of the number and energy of the single α-particles was not achieved.

The diamond crystals investigated up to now for crystal counters have very different properties, although all of them possess photoelectric saturation.

Some of the diamonds are quite insensitive to α-rays (P. J. Van Heerden; Wooldridge, Ahearn, and Burton).

Other crystals show the inhomogenous pulses mentioned above. It is of interest to note from the investigations of Wooldridge, Ahearn, and Burton that diamonds exist which possess the qualities necessary for a quantitative measurement of single α-particles.

[1] P. J. Van Heerden, *The Crystal Counter*, Dissertation, Utrecht 1945; D. E. Wooldridge, A. J. Ahearn, and J. A. Burton, Phys. Rev. **71**, 913 (1947); Robert Hofstadter, Bull. Am. Phys. Soc. **22**, No. 4 (1947).
[2] G. Stetter, Verh. d. D. Phys. Ges. **22**, 13 (1941).

Note on Gamma-Radiation from Europium

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November 19, 1947

On reporting the energies of the gamma-rays emitted by radioactive europium 154 it was noted that two spectral lines had the expected relative intensity and exactly the energy difference to be expected for conversion K and L electrons in the element of atomic number 61. This was interpreted as possibly indicating an impurity of neodymium in the bombarded specimen of europium, although no long half-lived isotope of neodymium is known. Continued observation has shown that this agreement with the K–L difference in element 61 is purely fortuitous and that these two lines have the same half-life as the other europium lines, namely, about 6 years. They are therefore K conversion lines in gadolinium, of energy 197.0 and 235.7 kev derived from gamma-rays of energy 247.3 and 286.0 kev. These new energies lead to an interesting combination as part of a level diagram since the 286 kev added to the previously reported 122.1 kev gives 408.1 kev, which is very close to the previously reported gamma-ray at 407.8 kev.

On Magnetism of Celestial Bodies

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November 12, 1947

The proportionality between the magnetic moment and the angular moment of celestial bodies in the case of 78 Virginis has recently been verified by Mr. H. Babcock.[1] It seems possible to give a theoretical interpretation of that new natural law in the following way.[2]

The motion of a continuous, perfect fluid, without internal pressure, in an electromagnetic field not sensibly perturbed by it, is given by the ordinary Lorentz force, which yields the equations:

$$du_i/ds=(\sigma_0/\rho_0c^2)F_{ij}u^j=w_{ij}u^j, \tag{1}$$

σ_0 being the proper charge density of the fluid, ρ_0 its proper mass density, $u^i=dx^i/ds$ its four-dimensional velocity at each point, $F_{ij}=\varphi_{i,j}-\varphi_{j,i}$ the external electromagnetic field (the gravitation effects being neglected). When σ_0/ρ_0c^2 is constant in the domain occupied by the fluid, we easily get:

$$w_{ij}=u_{i,j}-u_{j,i}=(\sigma_0/\rho_0c^2)F_{ij}, \tag{2}$$

from analytical dynamics, by writing (1) in canonical form; consequently,

$$u_i=(\sigma_0/\rho_0c^2)\varphi_i+\partial F/\partial x^i. \tag{3}$$

Thus, u_i may be regarded as a determination of φ_i, which seems to furnish a very natural geometrization of electromagnetic field, but, in classical electromagnetism, we are dealing in this way with several difficulties.

First, in the general case of a fluid charged in the Maxwellian sense σ_0/ρ_0c^2 has an arbitrary value; second, the φ_i are defined in the whole region occupied by the field and the u_i only interior to a certain light cone and require the presence of matter (from a remark of Professor Einstein), but we must notice that electromagnetic field has no existence "in self," contrarily to the classical assumption. For its determination at each point, we need at these points a fluid composed of test particles whose motion is governed by (1), otherwise the field remains indetermined.

In a peculiar case, we may determine uniquely σ_0/ρ_0c^2, in order to satisfy the theory. If we suppose that rotation and electromagnetic field are uniquely associated, when a fluid regarded as neutral in classical theory is in rotational